LOCAL WIRELESS AUDIO SIGNAL RF TRANSMITTER AND RECEIVER HAVING A SINGLE DOWNCONVERTER WITHOUT THE NEED FOR IF CARRIER

BACKGROUND OF THE INVENTION

1. Field of the Invention.

This invention relates to the wireless transmission and reception of audio signals utilizing a modulated carrier RF signal. More particularly, it relates to the wireless transmission and reception of audio signals for a set of audio headphones wherein a modulated RF carrier signal in the 900MHz range is employed to transmit the audio signals from a first stationary location (base unit) to a set of wireless audio headphones.

2. Background of the Prior Art

The transmission and reception of audio signals utilizing modulated RF carrier frequencies is well known in the prior art. The use of such technology to transmit audio signals from a base unit to a pair of wireless headphones is also known. In such use, the base unit is coupled to an audio processing device such as an audio receiver or amplifier which in turn is coupled to a CD player, phonograph player, radio receiver or other like audio producing device. The audio signal produced by one of these devices and processed by the audio receiver/amplifier is wirelessly transmitted to the

audio headphones by way of the base unit coupled to the audio receiver/amplifier. High frequency carrier waves are employed wherein the audio information is modulated upon the high frequency carrier wave, transmitted by an antenna coupled to the base unit, received by a receiver unit (wireless headphones) also having an antenna, subsequently demodulated and thereafter converted to an audio signal which is reproducible by the wireless headphones.

The use of high frequency carrier waves in the 900 MHz range is known and became a standard for such wireless technology after the US government made the 900 MHz frequency range available for use by consumer electronic manufacturers. However, the manner in which these carrier frequencies are modulated and subsequently downconverted has remained complicated. One example can be seen in US Patent No. 6,215,981 to Borchardt et al. In such patent, a 900 MHz modulated RF carrier signal is used to transmit an audio signal from a base unit to a local receiving unit, such as, for example, a pair of wireless headphones. When the 900 MHz carrier frequency is received, it is downconverted a first time to an IF (intermediate frequency) of about 65 MHz. Thereafter, a second downconversion is affected to produce a lower frequency that can be reproduced by an electro acoustical transducer (the speakers within the pair of

headphones). A standard FM radio receiver is coupled to the first downconverter and contains the second downconverter therewithin. The first downconversion converts the 900 MHz carrier signal to an intermediate frequency (IF) of 65 MHz signal. The second downconversion converts the signal to 10.7 MHz which is then demodulated into right and left audio signals which are reproducible by the electroacoustic transducers (speakers) of the wireless headphones. The second downconversion occurs in the standard FM radio receiver through the use of a VCO (voltage controlled oscillator) and a mixer. This prior art invention requires two downconversions, since the 65 MHz IF signal can not be demodulated into reproducible right and left audio signals. The 65 MHz IF signal is downconverted to a useable 10.7 MHz signal by the mixer after tuning the VCO to a suitable frequency level.

Since it would be desirous to simplify the transmission and reception process for this technology, improvements would be welcome. One such improvement could be to eliminate the need for two downconversions and hence the need for an IF carrier signal. This would certainly be an improvement in the art and represent a simplification of the transmission and reception process for wireless audio headphones.

SUMMARY OF THE INVENTION

We have invented an improved audio wireless headphone system utilizing modulated 900 MHz carrier signals to transmit audio signals emanating from a base unit coupled to an audio processing device to a receiver unit located within a pair of wireless audio producing headphones. Our improved wireless headphone system does not require two frequency downconversions. The IF carrier input signal is eliminated such that a modulated RF carrier frequency in the 900 MHz range is transmitted from the base unit to the wireless headphones and downconverted once within the headphones from the transmitted carrier frequency directly to a useable 10.7 MHz signal which is demodulated into reproducible right and left audio signals. Any VCO and mixer within the FM receiver of the headphones is not used as a second downconverter as practiced in the prior art. Instead, within an UHF module of the receiver, having a built in local oscillator and phase lock loop (PLL) circuit, the frequency can be changed by adjusting an outside crystal tuning circuit. In particular, the RF signal received by the antennae is mixed with the local oscillator frequency whereby the mixer directly converts the mixed signals to a 10.7 MHz signal which is subsequently demodulated into reproducible right and left audio signals. Accordingly, wherein we have invented a wireless transmission

system for use with audio headphones whereby a variable frequency tuning system is employed with a built in local oscillator employing a single downconversion, the prior art utilizes a local oscillation frequency, two downconversions with the tuning system in the receiver block portion of the circuit and not in UHF module.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention can be best understood by those having ordinary skill in the art by reference to the following detailed description when considered in conjunction with the accompanying drawings in which:

Figure 1 is a block diagram of a transmitter used in the wireless headphone system of the present invention;

Figure 2 is a block diagram of a receiver used in the wireless headphone system of the present invention; and

Figure 3 is a block diagram of a UHF module of the receiver used in the wireless headphone system of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Throughout the following detailed description, the same reference numerals refer to the same elements in all figures.

With reference to Figure 1, a transmitter circuit 10 used in the present invention is shown. Transmitter 10 is enclosed within a base unit (not shown) having a pair of audio input

jacks 12 which couple to an audio amplifier which in turn is coupled to one of any type of audio producing devices, such as, for example, a CD player, a phonograph player, a cassette player or an FM/AM radio receiver. The input jacks couple directly to a first part of transmitter 10. Transmitter 10 is divided into three parts. A first part is the audio signal processing circuit. The second part is the micro control unit and control circuit. And finally, the third part is the power supply circuit and the charge circuit.

With continuing reference to Figure 1, it is shown in the first part of transmitter 10 that input jacks 12 couple directly to an auto level control amplifier (ALC) circuit 14 thereby feeding an audio signal from the audio amplifier emanating from one of the many audio producing devices. After being amplified by auto level control amplifier circuit 14, both right and left signal are sent through an audio frequency (AF) low pass filter and pre-emphasis circuit 16. Thereafter, the audio signal is sent to a stereo multiplexer IC 18 which outputs a stereo multiplexed audio modulated signal. The multiplexed signal includes a left channel audio signal, a right channel audio signal and a pilot tone signal. The stereo multiplexed audio modulated signal is then sent to a UHF module 22 which modulates the signal up to a 912.5 MHz RF carrier signal (although other signals in the 900 MHz range

could be employed). A transmitting antenna 24 coupled to UHF module 22 then sends the modulated RF carrier signal out to a receiver unit within the local area.

With continuing reference to Figure 1, in the second part of transmitter 10, a CPU 26 is employed which is coupled to UHF module 22. CPU 26 contains a micro control unit and a control circuit which is in turn coupled to an auto power circuit made up of a first and second component 28 and 30. CPU 26 is controlled by the auto power circuitry and its ON/OFF signal and a band choose/change signal from a slide switch (not shown) and a change signal from a change signal circuit (also not shown). The micro control unit of CPU 26 sends a control signal to a phase lock loop (PLL) circuit within UHF module 22 to choose or change the RF frequency.

Again, with continuing reference to Figure 1, the third part of transmitter 10 is shown wherein a 12V AC/DC power supply adapter 32 is employed which is coupled to an 8V regulator circuit 34. This third part of transmitter 10 supplies all necessary supply power to all components of transmitter 10 with the voltage that is required of each component.

Auto level control (ALC) amplifier 14 is a monolithic integrated circuit consisting of a dual equalizer amplifier. The stereo audio signal input jacks 12 connect directly to

auto level control amplifier 14. If the input level is larger than the standard level, the output level would be limited and the output/input ratio would change.

Right and left audio frequency pre-emphasis circuits, a portion of AF filters 16, receive the audio signal output from ALC amplifier 14 and send it to the audio frequency low pass filters of AF filters 16 after passing through a resistor net. The two channel low pass audio frequency filters effectively remove high frequency audio noise above 15.625 kilocycles so that noise is reduced in the transmitted signal. This filtered signal from audio frequency filters 16 is then sent to a pre-emphasis circuit. Frequencies higher than 2 kilocycles are pre-emphasized, which is later de-emphasized by a de-emphasis circuit in the receiver headphone. This serves to improve the signal-to-noise ratio thereof. The resulting audio signal is then sent to stereo multiplexer IC 18.

Stereo multiplexer IC 18 is an integrated circuit used to generate a stereo composite signal. Stereo multiplexer IC 18 forms a baseband component representing the sum of left and right audio signals and a difference signal representing the difference between the left and right channel audio signal. This is sent to a built-in time-division-MPX which produces a multiplexed signal output. A left and right channel volume adjustor unit (not shown) can adjust the balance between the

two audio channels. After combining the signals, the multiplexed signal and the 19KHz pilot signal are sent to UHF module 22.

UHF module 22 includes a VCO (Voltage Controlled Oscillator), a PLL (Phase Lock Loop) circuit and a radio frequency amplifier. The VCO circuit produces a radio frequency of about 912MHz. The PLL circuit, controlled by a micro control unit (MCU) produces a voltage signal for the VCO circuit for choosing an appropriate radio frequency. This radio frequency is modulated by the combined multiplexed signal and the 19KHz pilot signal. After been amplified, this modulated RF signal is sent to the one-quarter wavelength transmitting antenna 24. And at last, the transmitted signal is radiated within a local transmission area which typically is within a distance of about one-hundred feet from the transmitter unit.

Transmitter 10 is controlled by micro control unit IC (MCU) 26. In the preferred embodiment, MCU 26 is an 8 bit micro controller with 1*13K of EPROM. In transmitter 10, MCU 26 deals with the power ON/OFF signal and the charge signal of first and second auto power components, 28 and 30 respectively, to control two LED lights (not shown) and the power supply of UHF module 22. MCU 26 further is designed to judge the state of a slide switch and an output control signal

to UHF module 22 for producing different radio frequencies. All of this control work is completed by firmware loaded onto MCU 26. When MCU 26 is operating, at first, it will judge the state of a charge signal. If there are batteries connected to transmitter 10, MCU 26 will shut off all other outputs so that transmitter 10 only works as a battery charger. If there are no batteries connected to transmitter 10, then MCU 26 will judge the power ON/OFF signal from another location. If there are no audio signal outputs from ALC amplifier 14, then there are no voltage signals to be sent, which makes a measurable voltage high whereby MCU 26 will then output low voltage signals so that a LED (not shown) is OFF. However, if there are audio signals outputted from ALC amplifier 14, the voltage of an output of MCU 26 is turned low causing MCU 26 to output a high voltage at another output to light the LED. MCU 26 then checks the state of the slide switch, wherein each of three states of the switch means different frequencies to be radiated out. MCU 26 checks the state and sends a control signal to the PLL unit within UHF module 22. MCU 26 can also receive a frequency signal from the PLL unit of UHF module 22 for comparing with the frequency created before. If these two frequencies are not the same, MCU 26 will send out a voltage control signal which will continue to operate until these two frequencies are the same.

With reference now to Figure 2, a receiver circuit 36 is shown. Receiver 36 includes a UHF module 38. A receiver antenna 40 is coupled to an input network 50 (see Fig. 3) which is located inside UHF module 38. The input network 50 is a high pass filter with its output connecting to an RF amplifier. UHF module 38 also includes a voltage controlled oscillator (VCO) with a phase locked loop (PLL) circuit and a mixer circuit. The RF amplifier is employed to boost the level of the received 900MHz range RF signal from antenna 40 (in the preferred embodiment, a 912.5MHz RF signal is employed). This amplified signal is then passed to the mixer circuit 52 in UHF module 38, as shown in Fig. 3.

The local oscillation is created by the VCO and controlled by the PLL circuit. The VCO frequency is detected by the PLL circuit and divided by a 64 prescaler. Thereafter, the divided signal is compared with a reference frequency, produced by a control circuit, for obtaining an error voltage. This error voltage is used to lock the VCO frequency.

With continuing reference to Fig. 3, the mixer circuit 52 of UHF module 38 serves to downconvert the received signal from the RF amplifier with the local oscillation frequency to create a useable 10.7MHz signal. This 10.7MHz signal is amplified and filtered and then outputted to an IF amplifier 54 built within UHF module 38. Thereafter the signal is sent

through a detector and stereo demodulation (within the integrated circuit of IF amplifier 54) resulting in right and left channel audio signals.

In order to catch the modulated RF signal transmitted by transmitter 10, a certain reference frequency is chosen to lock the local oscillation in the receiver 36 of the system. Thereafter, the mixer circuit 52 will output the 10.7MHz signal. For example, if a 912.5MHz signal is transmitted, a control circuit outputs a suitable frequency so that a 901.8MHz VCO frequency is outputted which results in the mixer circuit 52 outputting a useable 10.7MHz signal (the difference between the 912.5MHz and 901.8MHz signals). Accordingly, receiver 36 is tunable by changing the reference frequency produced by the control circuit.

With reference to Figure 2, the outputted right and left channel audio signals are then fed into a right and left channel EF AMP 42. After being amplified, the right and left channel signals are fed into an audio amplifier 44 through a filter network 46. Audio amplifier 44 amplifies the right and left channel signals to drive a pair of electroacoustic transducers or a pair of speaker elements with a set of wireless headphones. Audio amplifier 44 is a monolithic integrated circuit for use with stereo audio amplification.

Receiver 36 can receive three frequency signals by pressing a switch (not shown). The switch is connected to a CPU 48. When a signal switch is detected, CPU 48 begins to scan the RF signal transmitted by transmitter 10. Depending on its scanning result, CPU 48 selects a relevant crystal, or a proper reference frequency, to match to transmitter 10. CPU 48 is also employed to mute audio amplifier 44 when no signal is received.

Equivalent elements can be substituted for the ones set forth above such that they perform in the same manner in the same way for achieving the same result.